Strategic Plan

Defense Advanced Research Projects Agency

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DARPA's Strategic Plan

1. Introduction and Purpose

This report responds to the requirement in Senate Report 107-151 for the Defense Advanced Research Projects Agency (DARPA) to develop a strategic plan. Its purpose is to describe, in broad terms, DARPA's current top-level strategy to Congress, other elements in the Department of Defense (DoD), the research community, and other interested parties.

2. Overview of DARPA

2.1. DARPA's Mission, Management and Organization

DARPA's strategic plan begins with the Agency's mission:

> *DARPA's mission is to maintain the technological superiority of the U.S. military and prevent technological surprise from harming our national security by sponsoring revolutionary, high-payoff research that bridges the gap between fundamental discoveries and their military use.*

DARPA's mission implies one imperative for the Agency: radical innovation for national security. DARPA's management philosophy reflects this in a straightforward way: bring in expert, entrepreneurial program managers; empower them; protect them from red tape; and make decisions quickly about what projects need to be started and what projects should stop.

To maintain an entrepreneurial atmosphere and the flow of new ideas, DARPA steadily rotates program managers in and out of the Agency, with most program managers serving for only four years. The idea is that the best place to get new ideas is new people. New people also ensure that DARPA has very few institutional interests besides innovation, because new program managers are willing to redirect the work of their predecessors – and even undo it, if necessary.

Another notable feature of DARPA's management philosophy is that the Agency has very limited overhead and no laboratories or facilities. Again, the idea is to minimize any institutional interests that might distract the Agency from its imperative for innovation.

DARPA's current technical organizational structure is shown in Figure 1. This chart implies more formal structure than is actually the case at DARPA. In general, the character and mission of DARPA offices change over time as DARPA focuses on different areas. Offices are created and disbanded as DARPA changes direction.[1] The basic purpose of Offices is to create synergy by bringing together experts with similar interests so they can interact with each other. DARPA has found that bringing together people with the same interests can lead to a non-linear generation of ideas. The Office Directors' job is to recruit outstanding program managers and develop the office synergy, while keeping the program managers broadly on-track with the office theme. The Office theme or vision is set by the DARPA Director reflecting his interactions with the Service Secretaries and Chiefs, the Joint Chiefs of Staff and staff, and the Secretary of Defense and his staffs.

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[1] For example, in the past 15 months, two new offices, the Information Awareness and Information Exploitation Offices, were established in response to DARPA's current strategy, the focus of the Information Processing Technology Office was changed, and a DARPA-wide theme in space was created.

There are two basic DARPA technical offices: technology offices and systems offices. The technology offices are the Defense Sciences Office, Microsystems Technology Office, and Information Processing Technology Office. These offices focus on new knowledge and component technologies that might have significant national security applications. The system offices are the Tactical Technology Office, Special Projects Office, Advanced Technology Office, Information Exploitation Office, and Information Awareness Office. These offices focus on technology development programs leading to products that more closely resemble a specific military end-product, i.e., an item that might actually be in the military inventory. As a practical matter, there tends to be a fair amount of overlap between the two types of offices: the work in the technology offices often shapes the work of the systems offices, and vice-versa.

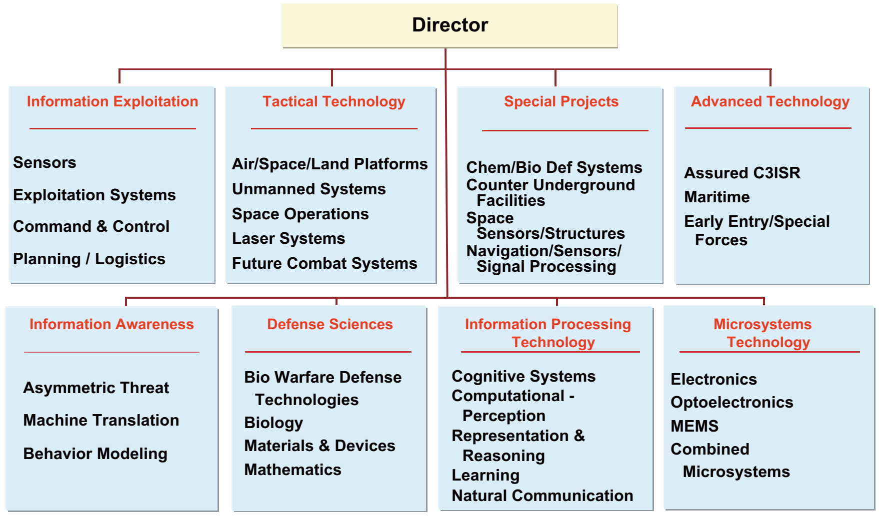

Figure 1: DARPA's organization.

DARPA has several special authorities to assist the Agency in carrying out its unique mission in accordance with its flexible management philosophy. For example, DARPA has an Experimental Personnel Authority[2] that allows the Agency to maintain its entrepreneurial edge by hiring expert program managers from industry at competitive salaries, and do it very quickly – much faster than under normal Civil Service rules.

DARPA also pioneered the use of Other Transactions Authorities[3], which allow much more flexible contracting arrangements with firms and universities than would normally be possible under the Federal Acquisition Regulations.

Finally, DARPA has the authority to award prizes to encourage technical accomplishments[4], similar to the prize awarded to Charles Lindbergh for his nonstop transatlantic flight to Paris. DARPA is making use of this authority for the first time to sponsor a race of fully autonomous, unmanned ground vehicles from Los Angeles to Las Vegas in April 2004, with a prize of $1,000,000.[5]

2.2. DARPA's Role in the Department of Defense

DARPA fulfills a unique role within the Department of Defense. As a Defense Agency, DARPA reports to the Secretary of Defense. The Director, Defense Research and Engineering has been

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2 5 USC 3104 Note

3 10 USC 2371 and 10 USC 2371 Note

4 10 USC 2374

5 http://www.darpa.mil/grandchallenge

assigned to be DARPA's Principal Staff Assistant (PSA). DARPA is the Secretary of Defense's only research agency not tied to a specific operational mission. DARPA supplies technological options for the entire Department. DARPA is designed to be the "technological engine" for transforming the Department of Defense.

This unique role is needed because near-term needs and requirements generally force the operational components to focus on nearer-term needs at the expense of major change. Consequently, a large organization like the DoD needs a place like DARPA whose *only* charter is radical innovation. DARPA looks beyond today's known needs and requirements because, as military historians have noted, "None of the most important weapons transforming warfare in the 20th century – the airplane, tank, radar, jet engine, helicopter, electronic computer, not even the atomic bomb – owed its initial development to a doctrinal requirement or request of the military."[6] *None* of them. And to this list, DARPA would add stealth and Internet technologies.

DARPA's Outreach

Among the individuals who have been briefed on major elements of DARPA's current strategy are:

- U.S. Vice President Richard B. Cheney
- Secretary of Defense Donald H. Rumsfeld
- Secretary of the Army Thomas E. White
- Secretary of the Navy Gordon R. England
- Secretary of the Air Force Dr. James G. Roche
- Chairman of the Joint Chiefs of Staff Gen. Richard B. Myers
- Under Secretary of Defense for Acquisition, Technology and Logistics Edward C. "Pete" Aldridge Jr.
- Army Chief of Staff Gen. Eric K. Shinseki
- Chief of Naval Operations Adm. Vern Clark
- Commandant of the Marine Corps Gen. James Jones
- Air Force Chief of Staff Gen John P. Jumper
- Commander, U. S. Strategic Command Adm. James O. Ellis Jr.
- Commander, U.S. Northern Command, Gen. Ralph E. Eberhart
- Commander, U.S. Joint Forces Command, Adm. Edmund P. Giambastiani, Jr.
- Commander, U.S. Special Forces Command, Gen. Charles R. Holland
- Director, Defense Research and Engineering Ronald M. Sega
- Assistant Secretary of the Army for Acquisition, Logistics and Technology Claude M. Bolton Jr., Major General, USAF (Ret.)
- Assistant Secretary of the Navy (Research, Development and Acquisition) John J. Young, Jr.
- Undersecretary of the Air Force Peter B. Teets
- Vice Commander, U.S. European Command, Gen. Carlton W. Fulford, Jr.
- Commander, Air Force Material Command Gen. Lester L. Lyles
- Director, Program Analysis and Evaluation Stephen A. Cambone
- Director, Force Structure, Resources and Assessment, J-8, Joint Chiefs of Staff, and Chairman, Joint Requirements Oversight Council Lt. Gen. James E. Cartwright

DARPA's approach is to imagine what a military commander would want in the future, and then accelerate that future into being – thereby changing people's minds about what is technologically possible today.

Figures 2 and 3 illustrate how DARPA works. These figures show where science and technology (S&T) funding is invested along a notional "time-line" from "Near" to "Far," i.e., indicative of how long it takes for an S&T investment to be incorporated into an acquisition program.

6 John Chambers, ed., The Oxford Companion to American Military History (New York: Oxford University Press, 1999) p. 791

The gold "bubble" on the Near side of Figure 2 represents most of the work of the Service S&T organizations. Service S&T tends to gravitate towards the Near side because the Services emphasize providing technical capabilities critical to the mission requirements of *today's* warfighter. This is excellent S&T, and it is crucial because it continuously hones such U.S. military capabilities, e.g., improving the efficiency of jet engines. However, it is typically focused on known systems and problems.

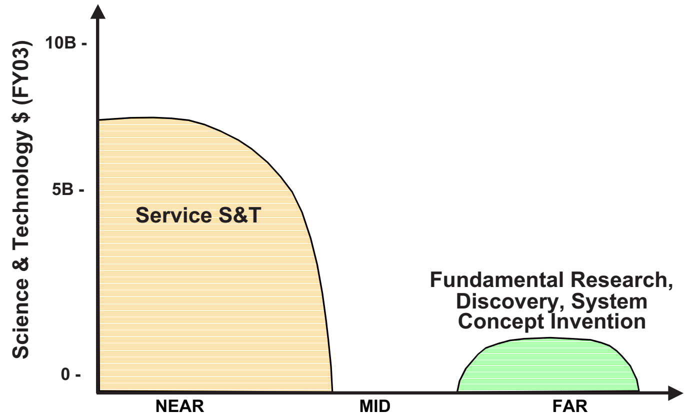

Figure 2: Timelines and investments in science and technology.

The small, green bubble on the Far side of Figure 2 represents fundamental discoveries, where new science, new ideas and radical new concepts typically first surface. People working on "the Far side" have ideas for entirely new types of devices, or new ways to put together capabilities from different Services in a revolutionary manner. But, the people on the Far side have a difficult, sometimes impossible, time obtaining funding from those on the larger Near side because of the Near side's focus on current, known problems.

DARPA was created to fill the gap between these two groups. Its mission, shown by the blue bubble in Figure 3, is to find the people and ideas on the Far side and accelerate those ideas to the Near side as quickly as possible. DARPA emphasizes what *future* commanders might want and pursues opportunities for bringing entirely new core capabilities into the Department. Hence, DARPA mines fundamental discoveries – the Far side – and accelerates their development and lowers their risks until they prove their promise and can be adopted by the Services. DARPA's work is high-risk and high-payoff precisely because it fills the gap between fundamental discoveries and their military use.[7] The inset discussion, "Shaping DARPA's Strategy," provides a more detailed discussion of how DARPA chooses its programs.

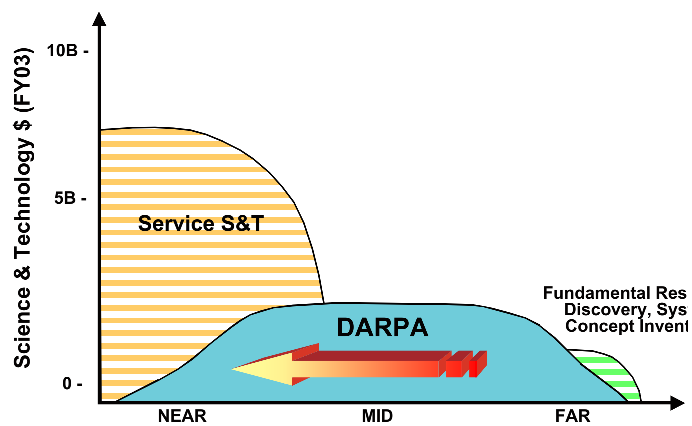

Figure 3: DARPA's role in science and technology.

Whenever there have been technological surprises, the people typically surprised are on the Near side. There are always a few people on the Far side who knew that something could be done, but

7 In line with DARPA's mission, only about 5 percent of DARPA's research is basic research. Basic research is inside the green bubbles and is primarily supported by the Service S&T organizations, with ONR having the primary role, and organizations like the National Science Foundation, the National Institutes of Health, and the Department of Energy. Basic research creates new knowledge and technical *capacity*, whereas DARPA creates new *capabilities* for national security by accelerating that knowledge and capacity into use.

Shaping DARPA's Strategy

Basic Challenge and Focus: A basic challenge for any military research organization is matching military problems with technological opportunities, including the new operational concepts those technologies make possible. Parts of this challenge are extremely difficult because: (1) some military problems have no easy or obvious technical solutions; and (2) some emerging technologies may have far-reaching military consequences that are still unclear. DARPA focuses its investments on this "DARPA-hard" niche – a set of technical challenges that, if solved, will be of enormous benefit to U.S. national security, even if the risk of technical failure is high. Other factors also shape DARPA's investments:

- DARPA emphasizes research the Services are unlikely to support because it is risky, does not fit their specific role or missions, or challenges existing systems or operational concepts;
- DARPA focuses on capabilities military commanders might want in the future, not what they know they want today;
- DARPA insists that all programs start with good ideas and good people to pursue them; without both these things, DARPA will not start a program.

Notable Features: DARPA's decision-making process is somewhat unusual for a government agency. It is informal, flexible, and yet highly effective because it focuses on making decisions on specific technical proposals based on the factors discussed above.

There are two reasons for this. DARPA is a small, flat organization rich in military technological expertise. There is just one porous management layer (the Office Directors) between the program managers and the Director. With less than 20 senior technical managers, it is easy to make decisions. This management style is essential to keeping DARPA entrepreneurial, flexible and bold. DARPA's management philosophy is to pursue fast, flexible, and informal cycles of "think, propose, discuss, decide, and revise." This approach may not be possible for most government agencies, but it has worked well for DARPA.

The Basic Process: DARPA uses a top-down process to define problems and a bottoms-up process to find ideas, involving the staff at all levels. DARPA's upper management and program managers identify "DARPA-hard" problems by talking to many different people and groups. (See "DARPA's Outreach" on p. 3) This process includes:

- Specific assignments from the Secretary of Defense or Under Secretary for Acquisition, Technology and Logistics;
- Requests for help from the Service Secretaries and Chiefs, Joint Staff, and Unified Combatant Commands;
- Discussions with senior military leaders on "What are the things that keep you awake at night?";
- Research into recent military operations to find situations where U.S. forces have limited capabilities and few good ideas;
- Discussions with Defense Agencies such as the Defense Threat Reduction Agency, the National Imagery and Mapping Agency, the Defense Information Systems Agency, and the Defense Logistics Agency;
- Discussions with the intelligence community such as the Central Intelligence Agency and the National Security Agency; and
- Discussions with other government agencies or outside organizations such as the National Science Foundation and the National Academy of Sciences.
- Visits to Service exercises or experiments.

During DARPA's program reviews, which occur throughout the year, DARPA's upper management looks for new ideas from program managers (or new program managers with ideas) for solving these problems. At the same time, management budgets for exploring highly speculative technology that have far-reaching military consequences.

Program managers get ideas from many different sources, such as:

- Their own technical communities;
- Suggestions from DoD-wide advisory groups, including the Defense Science Board and Service science boards;
- Suggestions from DARPA-sponsored technical groups, including the Information Science and Technology Study Group and the Defense Science Research Council;
- Suggestions from industry or academia, often in response to published Broad Area Announcements or open industry meetings such as DARPATech; and
- Breakthroughs in DARPA programs and/or U.S. or international research

Vetting a Program: During reviews of both proposed and on-going programs, DARPA's assessment is often guided by a series of questions. These seemingly simple queries help reveal if a program is right for DARPA.

- What is the project trying to do?
- How is it done now and what are the limitations?
- What is truly novel in the approach that will remove those limitations and improve performance? By how much?
- If successful, what difference will it make??
- What are the midterm exams required to prove the hypothesis?
- What is the transition strategy?
- How much will it cost?
- Are the programmatic details clear?

they could not obtain the resources to execute their ideas. By mining the Far side and plugging the gap between what might be done and what is done, DARPA prevents technological surprise for the U.S. and creates technological surprise for our adversaries by bringing forth technology that revolutionizes U.S. capabilities.

2.3. Some Major DARPA Accomplishments

Over the past four decades, DARPA and its management methodology have been very successful at "filling the gaps" in Figure 3.[8]

Figure 4 illustrates some of DARPA's preeminent accomplishments since the early 1960s.

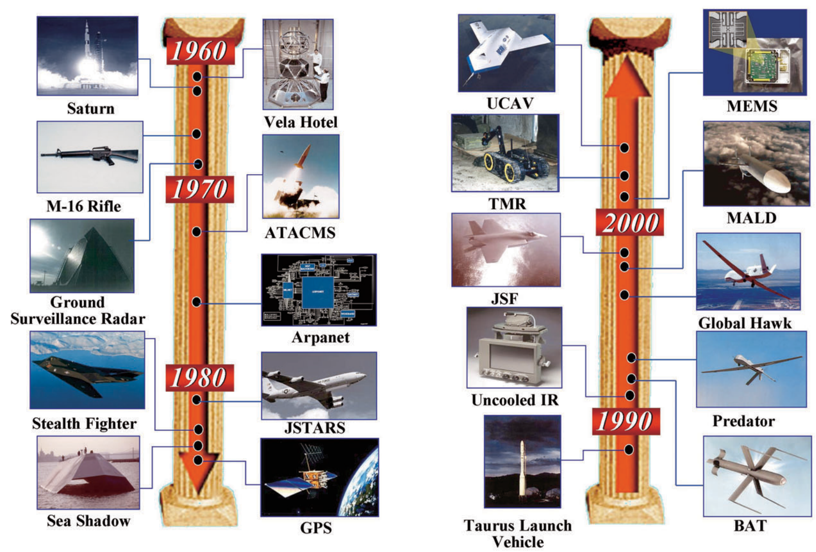

Figure 4: A summary of key DARPA accomplishments spanning more than four decades.

DARPA was borne of the space age. The launch of Sputnik in 1957 also launched DARPA, so the Agency's initial projects were all space-related. However, the Agency nearly ceased to exist when DARPA's space programs were transferred over to the National Aeronautics and Space Administration and the National Reconnaissance Office.

But a new mission came along to counter a threat that no Service or agency was tackling: ICBMs. From approximately 1960 to 1970, DARPA was the driving force behind the U.S.'s technology advancements in Ballistic Missile Defense. In 1968, the Army Ballistic Missile Defense Agency (ABMDA) was created and the ballistic missile defense mission was moved from DARPA to ABMDA.

In the 1960s, DARPA's Project AGILE pursued a modification of the Colt AR-15 rifle to develop what is now known as the M-16 assault rifle, the standard-issue shoulder weapon in the U.S. military.

DARPA began developing the technologies for stealthy aircraft in the early 1970s under the HAVE BLUE program, which led to prototype demonstrations in 1977 of the Air Force's F-117 tactical fighter that proved so successful in Operation Desert Storm. After the successes of the DARPA HAVE BLUE Stealth Fighter program, DARPA launched the TACIT BLUE Technology Demonstration, which contributed directly to the development of the B-2 bomber deployed by the Air Force. DARPA's stealth technology has also gone to sea: the SEA SHADOW, built in the mid-1980s, employs a faceted shape similar to that of the F-117 to

8 In Spring of 2003, a forthcoming Institute for Defense Analysis report will document the contribution DARPA system projects made to the Revolution in Military Affairs.

achieve reduced radar cross section, while the twin hull construction contributes to wake reduction and increased sea-keeping capabilities.

The Global Hawk and Predator Unmanned Aerial Vehicles have been prominent in Operation Enduring Freedom in Afghanistan and other parts of the world. DARPA began working on Global Hawk in the 1970s as the TEAL RAIN program; the Global Hawk high altitude endurance unmanned aerial vehicle (UAV) transitioned from DARPA to the Air Force in 1998. Development of Predator began in 1984 as DARPA's AMBER program. The Tier 2 Predator medium-altitude endurance UAV evolved directly from DARPA's AMBER and Gnat 750-45 designs, and was operationally deployed in the mid-90s.

And the most famous of all of DARPA's technology development programs is the Internet, which began in the 1960s-1970s with the development of the ARPANet and its associated TCP/IP network protocol architecture. DARPA's development of packet switching is the fundamental element of both public and private networks, and it spans the Department of Defense, the federal government, the U.S. industry, and the world (see Section 3.8).

A crucial characteristic to note about several of these accomplishments, which holds true for many DARPA programs, is that it took a long time from when the idea was first conceived to when it actually bore fruit and was used by the U.S. military. DARPA has shown itself very willing to tackle hard technical problems repeatedly, even in the face of previous failure, if the technology offers revolutionary new capabilities for national security. Patience and persistence are required attributes for those who pursue high risk technology, but they are often rewarded with extremely large payoffs.

2.4. Transitioning DARPA Technologies

Transitioning technology – getting technology from research and into use – is a difficult challenge, partly because so many different types of organizations may need to be involved, i.e., S&T organizations like DARPA, the acquisition community, the warfighting/requirements community, and the firms that actually produce the product. And the very nature of a technology strongly shapes how it transitions.

For example, a component technology, like a new material or microchip, is likely to get to the warfighter when a prime contractor incorporates it into a system, without the Service acquisition program necessarily having decided on it *per se*. This means the key decisions are made by industry – prime contractors and subcontractors. On the other hand, a large system development program, such as Global Hawk, requires the warfighting community to establish a formal requirement for the system, thereby charging the acquisition community with actually purchasing it. New systems simply do not "diffuse" their way into military use, like a new material might.

The transition challenge is exacerbated for DARPA because its focus is on high-risk, revolutionary technologies and systems, which may have no clear home in a Service, are Joint, or threaten to displace current equipment or doctrine. All these factors tend to create resistance, or at least barriers, to the use and adoption of a new technology.

Figure 5 is a simplified illustration of three methods DARPA uses to transition technology to the warfighter.

The first "bar" illustrates a significant part of DARPA's strategy. DARPA invests about 90 percent of its funds at organizations outside the federal government, primarily at universities and in industry. Over time, this investment leads to new capabilities in industry and steadily reduces the risks of the underlying technology. At some point a company finally becomes confident enough of its ability to make a new technology for a predictable cost and schedule that it will propose the technology to someone other than DARPA. DARPA's investment reduced the risk of a technology to the point where firms themselves are willing to make it, use it, or otherwise bid it back to the rest of the DoD.

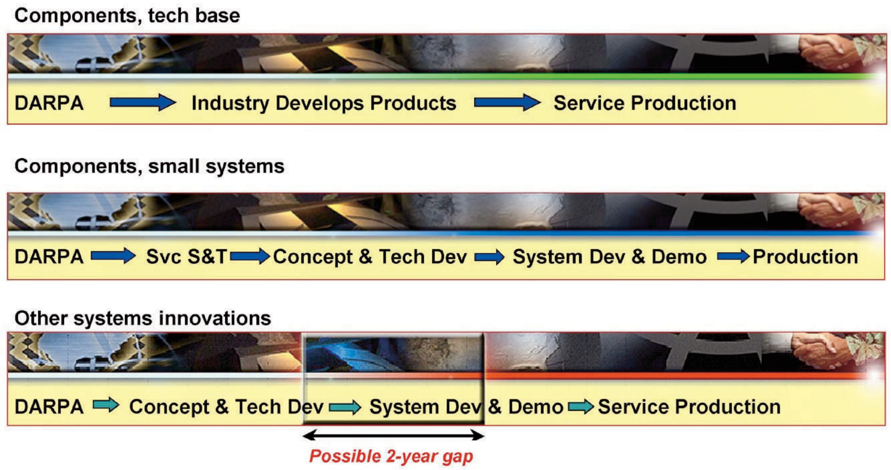

Figure 5: DARPA transition methods.

However, companies will not propose a new technology to a Service customer if they are not confident that the Service customer will accept it. The second bar in Figure 5 shows how DARPA removes this impediment. To build potential Service customers for DARPA technology – someone to whom these companies can bid with confidence – DARPA deliberately executes about 80 percent of its funding through the Services. That is, a Service organization acts as DARPA's agent and is the organization that actually signs the contracts with the research performers and monitors the day-to-day technical work. This creates a cadre of people inside a Service who are familiar with a DARPA technology, who can vouch for it, and who can shepherd it into a Service acquisition program. Once the company is confident that it can build a technology and a Service is willing to accept it, the technology then transitions and DARPA is, typically, forgotten.

DARPA occasionally builds prototype of a large, integrated system such as Global Hawk. Such programs reduce the risks in a new system to the point where the warfighting community can be confident that it will get a new and cost-effective capability. However, without proper planning such programs can run into a two-year "funding gap" between the time when the Service is convinced it wants the system and the time when the DoD's financial system can effectively respond. To prevent these and other problems, DARPA tries to ensure transition of prototypes by negotiating a Memorandum of Agreement with the Service adopting the system. The earlier the Memorandum of Agreement is negotiated, the better it works, since it is easier to plan the needed outyear funding ahead of time instead of trying to find it later.

In addition, to strengthen its connections with the Services, DARPA has military officers on staff who serve as "operational liaisons." These liaisons keep DARPA informed about what the Services might want, and they keep the Services informed about what DARPA is developing.

3. Current Strategic Thrusts

"Strategy" can be described as "the evolving pursuit of a central mission through changing circumstances." Consequently, over time, DARPA changes much of what it is doing in response to the different national security threats and technological opportunities facing the U.S.

As a result of this constant strategic reassessment, DARPA is emphasizing research in eight strategic thrusts. They are:

- Counter-terrorism
- Assured Use of Space
- Networked Manned and Unmanned Systems
- Robust, Self-Forming Networks
- Detect, Identify, Track and Destroy Elusive Surface Targets
- Characterization of Underground Structures
- Bio-Revolution
- Cognitive Computing

The following sections contain brief descriptions of each thrust and the forces driving it, along with some example activities within the thrust.

3.1. Counter-terrorism

Protection against acts of terror and the networks that perpetrate them is foremost in everyone's mind today. DARPA has a counter-terrorism strategic thrust with two major elements.

One element, Information Awareness, has been greatly expanded as a direct result of the September 11th attacks. Its goal is to create information systems that America's national security and law enforcement communities can use to detect and defeat terrorist networks – perhaps preventing a terrorist attack and even eliminating the need for a major military operation.

IAO is *not* building a "supercomputer" to snoop into the private lives or track the everyday activities of American citizens. Instead, IAO is developing and integrating information technology that largely consists of three parts – advanced collaborative and decision support tools, language translation technologies, data search and pattern recognition technologies. Together, these three parts effectively comprise the Total Information Awareness (TIA) project.

The collaborative reasoning and decision-support technologies will solve existing coordination problems by enabling analysts from one agency to collaborate effectively with analysts in other agencies. A major challenge to terrorist detection today is the inability to quickly search, correlate and share data from databases maintained legally by our intelligence, counterintelligence, and law enforcement agencies. The collaborative reasoning and decision-support technologies will punch holes into these "stovepipes."

The language translation technologies will enable the rapid translation of foreign language speech and text and give analysts from intelligence, counterintelligence, and law enforcement agencies the ability to quickly search for clues about emerging terrorist acts. The intelligence community believes it can find evidence of terrorist activities in open source foreign language publications and broadcasts. The rapid translation technologies will help analysts search a significant amount of material in a much shorter period than is possible today.

The research into data search and pattern recognition technologies is based on the idea that terrorist planning activities or a likely terrorist attack could be uncovered by searching for patterns indicative of terrorist activities in vast quantities of data. Terrorists must engage in certain transactions to coordinate and conduct attacks against Americans, and these transactions leave signatures (form patterns) that may be detectable. For this research, the TIA project will only use data that is legally obtainable and usable by the U.S. Government.

If the project is successful, the national security community and the Department of Homeland Security will consult with Congress to determine whether the TIA technology should be implemented for domestic use. The DoD will consult with Congress on how best to implement TIA technology for protection of U.S. forces overseas.

The DoD recognizes American citizens' concerns about privacy invasions. The Department has safeguards in place to ensure the TIA project will *not* violate the privacy of American citizens. As part of the TIA effort, IAO will research and develop privacy protection and other technologies to prevent abuses and external threats and ensure that data is protected and used only for lawful purposes.

Some individuals have questioned the role of the DoD and DARPA in this area. In its 44-year history, DARPA has undertaken numerous high-risk research efforts that led to significant capabilities. Many existing information technologies – including the Internet – started as advanced DARPA research projects. DARPA has had in the past joint programs with the FBI and the US Customs developing technology that could be used for detecting explosives and drugs at Airports and Sea Ports.

IAO follows a similar path of technical innovation with its research into advanced information capabilities that will give the United States a decisive edge in the global war on terrorism. All Americans share the frustration associated with vague warnings of terrorist threats. It is believed that IAO and its TIA project will help the U.S. Government reduce those generic reports to advance notice of specific threatening acts.

The second element of DARPA's counter-terrorism strategic thrust is Biological Warfare Defense (BWD). DARPA's BWD program began in the mid-1990s in response to a growing awareness that changes in the strategic and technological environment had sharply increased the biological warfare threat to the United States. DARPA's BWD program is comprehensive and aggressive. It covers sensors to detect an attack, technologies to protect people in buildings and manage the response to an attack, vaccines to prevent infection, therapies to treat those exposed, and decontamination technologies to recover the use of an area.

An excellent example of this work is the Unconventional Pathogen Countermeasures (UPC) program. The UPC program is working to create vaccines and therapies effective against any biological warfare threat, known or unknown, natural or engineered. In work that was accelerated because of the anthrax attacks on the Congress, the UPC program has supported what promises to be a major breakthrough in treating anthrax by using lysins, a development featured on the cover of *Nature* earlier this year[9].

3.2. Assured Use of Space

The national security community, generally, and the U.S. military, in particular, use space to provide warning, intelligence, communications, and navigation. These orbiting assets are one of the great advantages that the U.S. military has over potential adversaries. American society also uses space for similar purposes, making space assets an important element of the U.S. economy and way of life.

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9 *Nature* Issue 6900, August 22, 2002, Volume 418

This military advantage and civil dependency has not gone unnoticed, and there is no reason to believe that it will remain unchallenged or untested forever. As the Rumsfeld Commission explained, "An attack on elements of U.S. space systems during a crisis or conflict should not be considered an improbable act. If the U.S. is to avoid a 'Space Pearl Harbor,' it needs to take seriously the possibility of an attack on U.S. space systems."[10]

DARPA began as a space agency, when the shock of Sputnik caused Americans to believe that the United States' Cold War adversary had seized "the ultimate high ground." DARPA once again is investing in that arena.

In FY 2002, the Secretary of Defense directed DARPA to begin an aggressive effort to ensure that the U.S. military retains its pre-eminence in space by maintaining unhindered U.S. access to space and protecting U.S. space assets from attack. Figure 6 depicts a conceptual framework for DARPA's space strategic thrust with five elements:

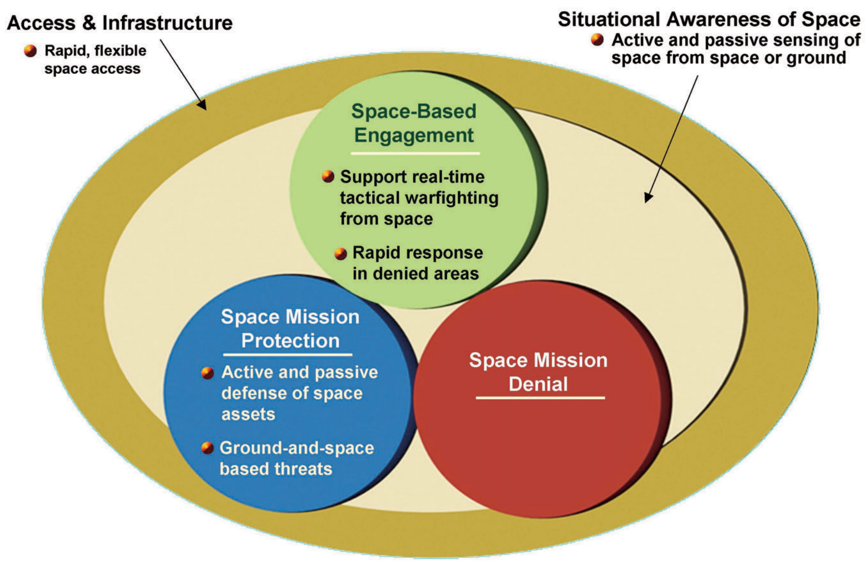

Figure 6: The five elements of DARPA's space program.

- **Access and Infrastructure** refers to rapid and affordable access to space;
- **Situational Awareness** refers to knowing what else is in space and what it is doing;
- **Space Mission Protection** refers to protecting U.S. assets in space from harm;
- **Space Mission Denial** refers to preventing adversaries from using space to harm the U.S. or its allies; and
- **Space-Based Engagement** refers to sensing, communications, and navigation to support military operations down on earth – extending what the U.S. does so well today.

DARPA is focusing most of its efforts on the first four of these thrusts, while the efforts in Space Based Engagement are emphasizing technology complementary to research being done by the Air Force and National Reconnaissance Office.

[10] *Report of the Commission to Assess United States National Security Space Management and Organization*, Hon. D. H. Rumsfeld, Chairman (January 11, 2001)

Three examples of DARPA's space programs are Responsive Access, Small Cargo, Affordable Launch (RASCAL), Orbital Express, and the Space Surveillance Telescope (SST). RASCAL is designed to place small payloads in orbit on a moment's notice by launching them from a high-speed, high-altitude aircraft that eliminates a large and expensive first stage booster. Orbital Express will demonstrate the feasibility of using automated spacecraft to refuel, upgrade, and extend the life of on-orbit spacecraft. This will lower the cost of doing business in space and will provide radical new capabilities for military spacecraft, such as high maneuverability (which would make our satellites more difficult to track and to evade), autonomous orbital operations, and satellites that can be reconfigured as missions change or as technology advances. The SST program is developing a ground-based, wide-aperture, deep field-of-view optical telescope. This telescope will search for very faint objects in geosynchronous orbit, e.g., new and unidentified objects that suddenly appear with unknown purpose or intent.

DARPA's programs are in full support of the National Aerospace Initiative, including hypersonic flight programs.

3.3. Networked Manned and Unmanned Systems

DARPA is working with the Army, Navy, and Air Force toward a vision of filling the battlespace with unmanned systems that are networked with manned systems. The idea is not simply to replace people with machines, but to team people with robots to create a more capable, agile, and cost-effective force that lowers the risk of U.S. casualties. The recent use of UAVs in Afghanistan has just begun to demonstrate the potential of this idea.

DARPA has been working on this strategic thrust for the past several years. Much, although not all, activity in this area is expected to transition to the Services within the next few years.

Two broad trends have combined to make this thrust feasible. First, there is an increasing appreciation within the Services that combining unmanned with manned systems can enable new combat capabilities or new ways to perform hazardous missions. Second, improved processors and software permit the major increases in on-board processing needed for unmanned systems to handle ever more complex missions in ever more complicated environments.

A prominent program in this area is Future Combat Systems (FCS), which DARPA is conducting with the Army. FCS is catalyzing the Army's transformation to the Objective Force. It will be a networked system-of-systems that includes manned and unmanned ground vehicles, along with various unmanned air vehicles. The goal is to develop Units of Action that have the lethality and survivability of an M1-based heavy force, but with the agility of today's light forces. FCS brigades will be able to deploy anywhere in the world within 96 hours.

DARPA is also conducting three unmanned air combatant programs: the Unmanned Combat Air Vehicle (UCAV) with the Air Force (see Figure 7), UCAV-N with the Navy, and the Unmanned Combat Armed Rotorcraft program with the Army. These aircraft will be teamed with manned systems on the ground and in the air to transform how the Air Force suppresses enemy air defenses, how the Navy suppresses enemy air defenses and conducts extended surveillance, and how the Army conducts armed reconnaissance and attack.

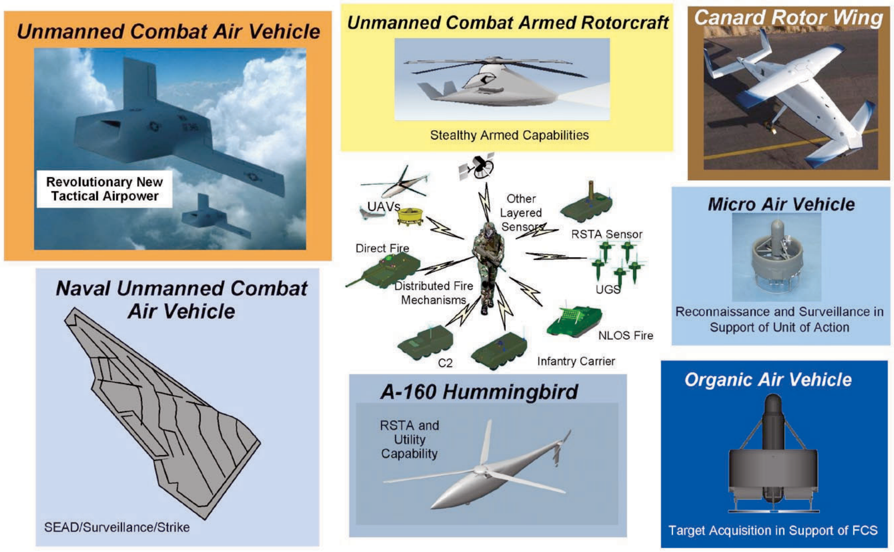

Figure 7: DARPA's Unmanned Systems programs.

3.4. Robust, Self-Forming Networks

The Department of Defense is in the middle of a transformation to what is often termed "Network Centric Warfare." In simplest terms, the promise of network centric warfare is that networked military systems will change the terms of any conflict in the U.S. military's favor. It will allow the U.S. and its allies to go beyond a correlation of local forces by providing them better information and letting them plan and coordinate attacks far more quickly and effectively than the adversary. In essence, networking is using "better brains" to create a more agile and effective brawn.

> **Network Centric Warfare**
>
> *An information superiority-enabled concept of operations that generates increased combat power by networking sensors, decision-makers, and shooters to achieve shared awareness, increased speed of command, higher tempo of operations, greater lethality, increased survivability, and a degree of self-synchronization. In essence, Network Centric Warfare translates information superiority into combat power by effectively linking knowledgeable entities in the battlespace.*
>
> —*Network Centric Warfare*, DoD C^4 ISR Cooperative Research Program

At the heart of this concept are survivable, assured communications at strategic and tactical levels. The intent is a network that degrades softly under attack, while always providing a critical level of service. The basic construct of a Joint Network Centric Warfare network is shown in Figure 8. DARPA continues its revolutionary thrust to ensure that U.S. forces will have secure, assured, multi-subscriber, multi-purpose (e.g., maneuver, logistics, Intel) networks for the future unified forces. This means conducting research in areas including self-forming networks, software programmable radios, spectrum management, and low probability of detection/intercept/exploitation communications.

The Adaptive Joint Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C^4ISR) Node Advanced Concept Technology Demonstration (AJCN ACTD) program is a prime example of DARPA's research activities in network communications. The AJCN ACTD is a multi-purpose, reconfigurable "radio frequency device in the sky." The program, just getting underway, will be a single system that can simultaneously

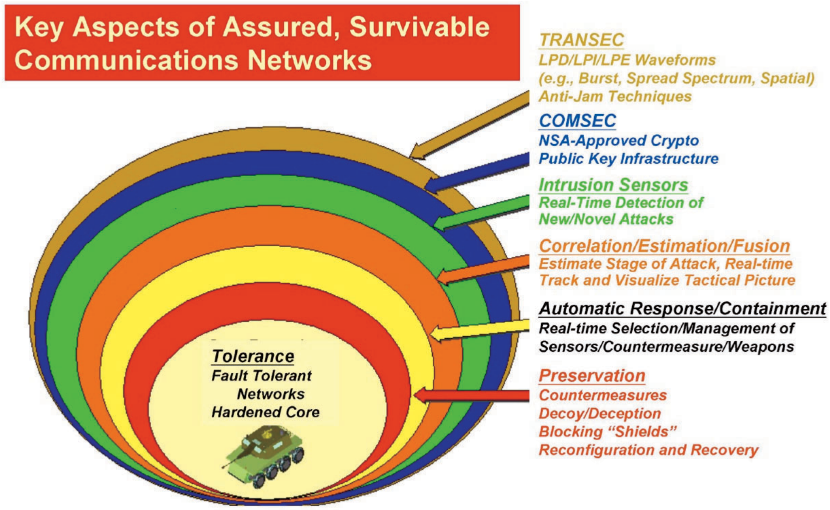

Figure 8: Protection of a Network-Centric Warfare network.

do any and all of the following: link up previously incompatible radios; conduct signals intelligence; conduct electronic warfare; and conduct information warfare.

DARPA's Small Unit Operations Situational Awareness System (SUO SAS) has developed a self-forming, self-healing communication system for dismounted warfighters operating in difficult and complex environments, such as urban and wooded terrains. The SUO SAS network allows the warfighter to covertly and securely communicate with his fellow squad members and automatically reports all squad member position locations, enabling both mission planning and mission execution monitoring. In October 2002 at Fort Benning, GA, the Army conducted a highly successful demonstration of using SUO SAS to help rescue a downed aircrew trying to escape capture in a city – a situation modeled on the events in Mogadishu, Somalia, in 1993.

The TeraHertz Operational Reachback (THOR) program is developing affordable, lightweight, and small high-speed optical communications networks for mobile and expeditionary forces without requiring laying down fiberoptic cable in-theater. THOR's long-term goal is to use emerging commercial technology to achieve data transfer rates of 10 gigabits per second over a 400 kilometer aircraft-to-aircraft link, a 40-fold improvement over current, high-data rate military communication systems.

A final example is the neXt Generation Communications program, which will make 10 to 20 times more spectrum available to the U.S. military by dynamically allocating spectrum across frequency, time, and space (see Figure 9). This capability has been described as "tuning for daylight."

3.5. Detect, Identify, Track, and Destroy Elusive Surface Targets

The Department of Defense has steadily improved its ability to conduct precision strike for many years. As a result, the war in Afghanistan showed that, in the words of the Chairman of the Joint Chiefs, "... the bomb is no longer solely an area weapon, but is going to be used like bullets from a rifle, aimed precisely and individually."[11] Timely, accurate, and precise delivery of bombs and missiles helped the U.S. overthrow a hostile regime in short order with very few American or

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[11] Gen. Richard Myers, Chairman of the Joint Chiefs of Staff, Oral Testimony before the Senate Armed Services Committee, February 5, 2002.

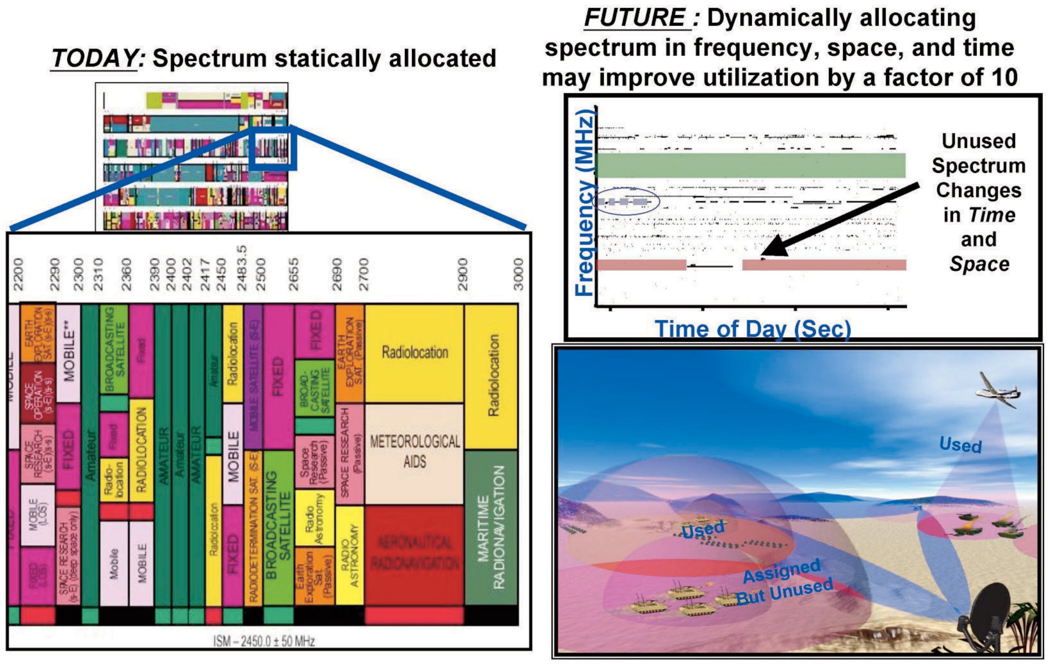

Figure 9: The neXt Generation Communication program

unintended casualties. Yet, experience has also shown that major challenges remain in target detection, identification, and tracking. It is still difficult to strike targets that are hiding, moving, or that require a rapid reaction by U.S. forces in order to be destroyed.

To provide a focused response to these challenges, DARPA established the Information Exploitation Office (IXO) in November 2001. IXO is assembling the sensors, exploitation tools, command systems, and information technologies needed to rapidly find and destroy ground targets in any terrain, in any weather, moving or not, at any time, with minimum accidental damage or casualties. To do this, IXO is working to seamlessly meld sensor tasking with strike operations, leveraging the development of platforms that carry both capable sensors and effective weapons. Of course, this implies blurring or even erasing barriers between the Intelligence and the Operations functions at all levels of command. This is a difficult technical challenge that requires a joint approach with potentially large implications for U.S. military doctrine and organizations – truly a DARPA-hard problem.

IXO is supporting research in four general areas: sensors to find targets; sensor exploitation systems to identify and track targets; command and control systems to plan and manage the use of sensors, platforms, and weapons throughout the battlespace; and information technology to tie it all together and ensure the effective dissemination of information.

A good example of IXO's efforts is the Affordable Moving Surface Targeting Engagement (AMSTE) program. AMSTE is demonstrating (see Figure 10) how, by making only minor modifications to existing and planned systems, U.S. forces can integrate information from multiple radars to precisely and rapidly destroy individual moving ground vehicles with a low-cost, GPS-guided gravity bomb like the Joint Direct Attack Munition (JDAM).

Another example of DARPA's work in time-critical precision strike is the Advanced Tactical Targeting Technology (AT3) program. By sharing the measurement of radar signals, AT3 can leverage non-dedicated platforms, such as fighters, to detect and locate enemy surface-to-air

Figure 10: AMSTE directs a Joint Stand Off Weapon (JSOW) to a direct hit on a moving tank during 2002 field experiments.

radars to an accuracy of 50 meters, from 50 miles away, and within 10 seconds after the enemy's radar turns on – a dramatic improvement over today's capabilities.

IXO is also developing tools to extract precise target identification from many different sources of data. Because many of our recent and potential adversaries invent or modify their weapons, programs such as Exploitation of 3D Data are developing techniques to recognize parts of vehicles (missile launchers, gun barrels, treads) that characterize threats, rather than specific vehicle types.

3.6. Characterization of Underground Structures

Many potential U.S. adversaries are well aware of the U.S. military's sophisticated ISR capabilities and global reach, so they have been building deeply buried underground facilities to hide what they are doing and to harden themselves against attack. These facilities can vary from the clever use of caves to complex, carefully engineered bunkers. Such installations can be used for a variety of purposes, including ballistic missiles, leadership protection, command-and-control, and the production of weapons of mass destruction.

To meet the challenge posed by the spread of these facilities, DARPA has a Counter-Underground Facility program (see Figure 11). The program is developing and using a variety of sensor technologies – seismic, acoustic, electro-optical, radio frequency, and chemical – to characterize underground facilities. The program is working on tools to answer the questions, "What is this facility for? How busy is it now? What are its structures and vulnerabilities? How might it be attacked? Did our attack destroy the facility?" The ability to answer these questions accurately will go a long way towards limiting the threat from underground facilities.

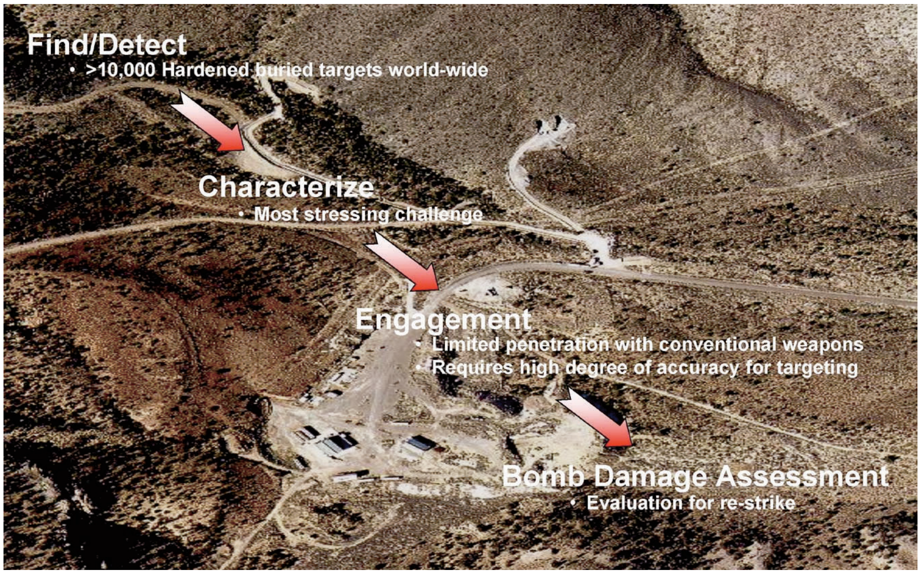

Figure 11: Counter-Underground Facilities program.

3.7. Bio-Revolution

DARPA has a strategic thrust in the life sciences called "Bio-Revolution." This thrust is a comprehensive effort to harness the insights and power of biology to make U.S. warfighters and their equipment stronger, safer, and more effective. It stems from several developments:

First, over the last decade and beyond, the U.S. has made an enormous investment in the life sciences – so much so that it has now become commonplace to say that we are entering a "golden age" of biology. One would be hard-pressed to find a better example of the far right-hand side of Figure 2 than the plethora of fundamental new discoveries being reported every day in the life sciences. DARPA is mining these new discoveries for concepts and applications that could enhance U.S. national security in revolutionary ways.

Second, there has been a growing recognition of synergies among biology, information technology, and micro/nano technology. Advances in any one area often benefit the other two, and DARPA has been active in information technology and microelectronics for many years.

Third, DARPA's programs to thwart the threat of biological attack have brought significant biological expertise into the Agency. This created an impetus and a capability to begin a major exploration of the national security potential of cutting-edge research in the life sciences.

The bio-revolution thrust has four broad elements, as shown in Figure 12:

- **Protecting Human Assets** refers to the BWD work described above in the "Counter-terrorism" strategic thrust (Section 3.1). BWD was the seminal activity of the Bio-Revolution at DARPA and, therefore, is also included here.
- **Enhanced System Performance** refers to creating new systems with the autonomy and adaptability of living things by developing materials, processes, and devices inspired by living systems. For example, DARPA-supported researchers are studying how geckos climb walls and how an octopus hides to find new approaches to locomotion and highly adaptive camouflage. The idea is to let nature be a guide toward better engineering.

- **Enhanced Human Performance** is aimed at preventing humans from becoming the weakest link in the U.S. military. The goal is to exploit the life sciences to make the individual warfighter stronger, more alert, more endurant, and better able to heal.
- **Tools** are the variety of techniques and insights on which the other three areas rest.

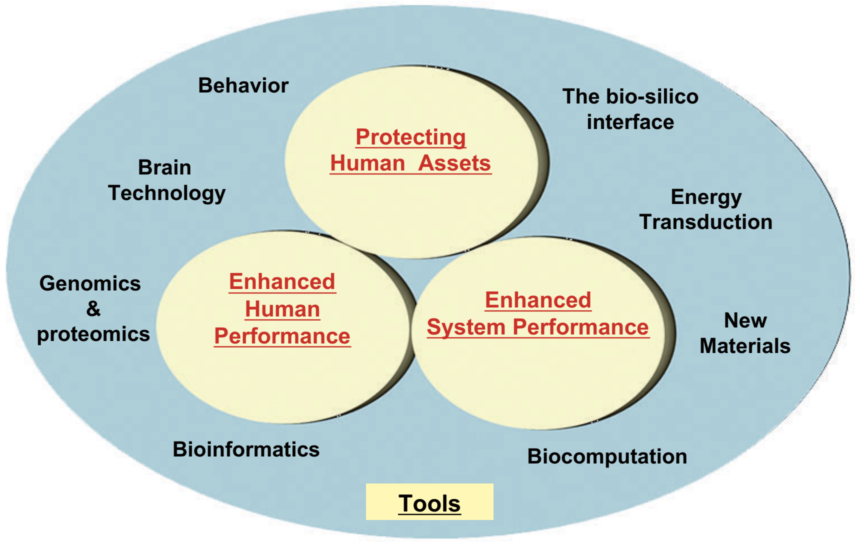

Figure 12: The four elements of DARPA's Bio-Revolution thrust.

DARPA's Continuous Assisted Performance (CAP) program illustrates how the Bio-Revolution is aimed at helping U.S. warfighters. CAP is investigating ways to prevent fatigue and enable soldiers to stay awake, alert, and effective for up to seven days straight without suffering any deleterious mental or physical effects and without using any of the current generation of stimulants.

Perhaps the program that best exemplifies the "revolution" in Bio-Revolution is the Brain Machine Interface program (see Figure 13). This program is finding ways to detect and directly decode signals in the brain so that thoughts can be turned into acts performed by a machine. Essentially, this program is working on ways for machines to synchronize with minds and then act directly on thoughts. This has actually been demonstrated, to a limited degree, with a monkey that has been taught

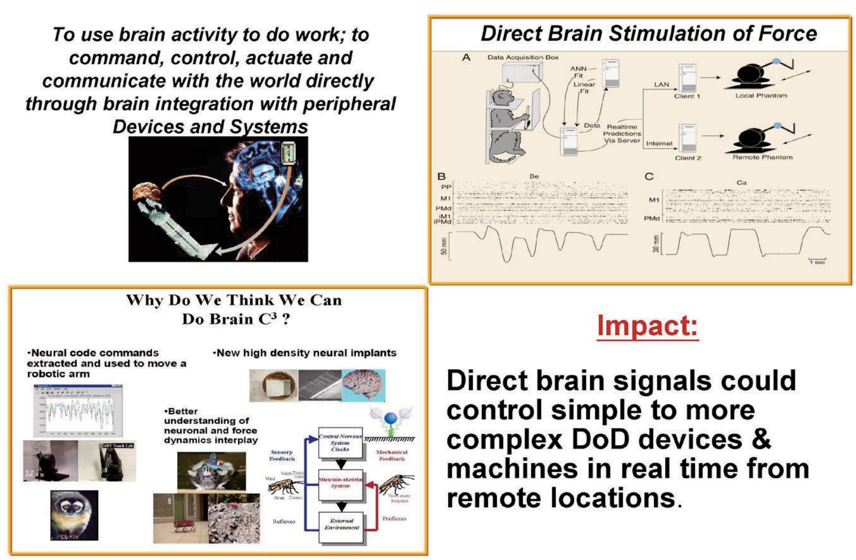

Figure 13: Brain-Machine Interface program.

to move a computer mouse or a telerobotic arm simply by thinking about it. The long-term Defense implications of finding ways to turn *thoughts into acts*, if it can be developed, are enormous: imagine U.S. warfighters that only need use the power of their thoughts to do things at great distances.

3.8. Cognitive Computing

Many elements of the information technology revolution that have vastly increased the effectiveness of the U.S. military and transformed American society – time-sharing, interactive computing, the ideas behind the personal computer, the Internet – were spurred on by the vision of a scientist at DARPA in the 1960s and 1970s, J. C. R. Licklider. Licklider's vision was of people and computers working together symbiotically. His concept was of computers seamlessly adapting to people as partners that handle routine information processing tasks. This frees people to focus on what they do best – think analytically and creatively – and, thereby, greatly extend the powers of their minds, i.e., what they can know, understand, and do.

Despite the enormous and continuing progress in information technology over the years, it is clear that we are still quite short of Licklider's vision. While current information systems are critical to U.S. national defense, they remain exceedingly complex, expensive to create and debug, unable to easily work well together, insecure, and prone to failure. And, they still require the *user* to adapt to *them*, rather than the other way around. Computers have grown ever faster, but they remain fundamentally unintelligent and difficult to use. Something dramatically different is needed.

In response, DARPA's Information Processing Technology Office (IPTO) is returning to its "roots" to take on Licklider's vision again in a strategic thrust called "Cognitive Computing." Cognitive computers can be thought of as systems that know what they are doing. Cognitive computing systems will have the ability to reason about their environment (including other systems), their goals, and their own capabilities. They will be able to learn both from experience and by being taught. They will be capable of natural interactions with users and will be able to explain their reasoning in natural terms. They will be robust in the face of surprises and avoid the brittleness and fragility of previous expert systems.

There are a number of reasons to believe the time is ripe for a more successful attempt at completing Licklider's vision. First, artificial intelligence and related disciplines, such as speech processing and machine learning, have made great strides in the last 20 years. Second, continuing rapid improvements in microelectronics are leading to the point where circuits with the complexity of primate brains are actually foreseeable (see Figure 14). Third, the on-going revolution in neural and brain science should provide insights into how people actually think, which can then be applied to computers.

To meet this challenge and opportunity, DARPA will focus on six core research areas over the next few years: computational perception; representation and reasoning; learning, communications and interaction; dynamic coordinated teams of cognitive systems; and robust software and hardware infrastructure for cognitive systems. The theoretical work in these areas will be focused by emphasizing several specific, but different, applications. The strategic thrust of Cognitive Computing will serve as a template to reshape DARPA's enduring foundational work in information technology (see Section 4.3).

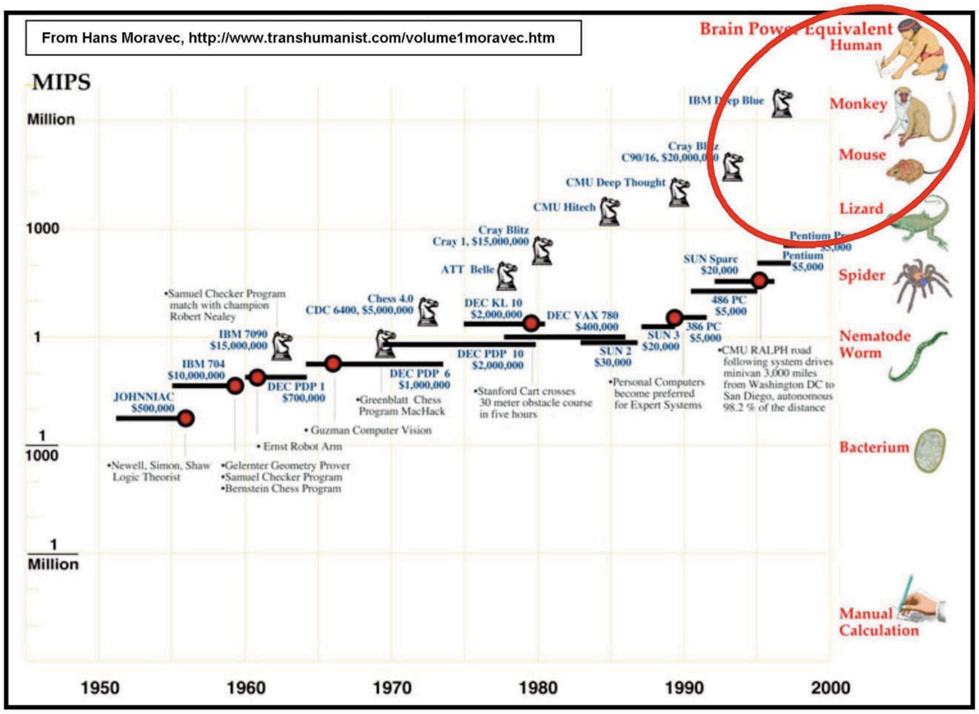

Figure 14: Microelectronics circuits as complex as primate brains are foreseeable.

If DARPA succeeds in this strategic thrust, just now getting underway, then in another 10 to 20 years, much of Licklider's vision may finally be realized, sparking a second powerful revolution in information technology.

4. Enduring Foundations

While DARPA's eight strategic thrusts are strongly driven by national security threats and opportunities, a major portion of DARPA's research emphasizes areas largely independently of current strategic circumstances. These "Enduring Foundations" are the investments in fundamentally new technologies, particularly at the component level, that historically have been the technological feedstocks enabling quantum leaps in U.S. military capabilities. DARPA is sponsoring research in materials, microsystems, information technology and other technologies that may have far-reaching military consequences.

In fact, these technologies often form enabling chains. Advanced materials have enabled new generations of microelectronics, which, in turn, have enabled new generations of information technology. And information technology is the enabling technology for Network Centric Warfare, discussed in Section 3.4.

DARPA's support of these enduring foundations naturally flows into its eight strategic thrusts with a fair amount of productive overlap. For example, some of the work under the Bio-Revolution thrust could also be considered part of the materials work and the information technology work is being reshaped by the Cognitive Computing thrust.

With this in mind, over 40 percent of DARPA's budget can be considered as devoted to high-risk, high-payoff component technologies. This figure is consistent with a goal established by the Undersecretary of Defense (Acquisition, Technology and Logistics) that at least 40 percent of DARPA's research be for "core technologies."

4.1. Materials

The importance of materials technology to Defense systems is often underestimated. In fact, many fundamental changes in warfighting capabilities have sprung from new or improved materials. The breadth of this impact is large, ranging from stealth technology, which succeeds partly because materials can be designed with specific responses to electromagnetic radiation, to information technology, which has been enabled by advances in materials for computation and memory.

In keeping with this broad impact, DARPA has maintained a robust and evolving materials program. DARPA's approach is to push those new materials opportunities and discoveries that might change way the military operates. In the past, DARPA's work in materials has led to such technology revolutions as new capabilities in high-temperature structural materials for aircraft and aircraft engines, and the building blocks for the world's microelectronics industry. The materials work DARPA is supporting today is building on this heritage of major contributions.

DARPA's current work in materials includes the following areas:

- **Structural Materials –** low-cost, ultra-lightweight structural materials and materials designed to accomplish multiple performance objectives in a single system;
- **Functional Materials –** material with a non-structural function such as advanced materials for semiconductors, photonics, magnetics, and other electronic materials;
- **Mesoscopic Machines –** materials that can be used for air or water purification and harvesting water from the environment;
- **Smart Materials and Structures –** materials that can sense and respond to their environment; and
- **Power Generation and Storage –** materials focused on novel ways to generate and store electric power, e.g., advanced fuel cells and materials to extract energy from the environment.

For example, DARPA's Structural Amorphous Metals (SAM) program is advancing a new class of bulk materials with amorphous or "glassy" microstructures. As a result of this microstructure, SAM alloys have unique and previously unobtainable combinations of hardness, strength, damage tolerance and corrosion resistance. Possible uses for SAM alloys include corrosion-resistant, non-magnetic hulls for ships; lightweight alloys for aircraft and rocket propulsion; and self-sharpening penetrators. DARPA's Initiative in Titanium aims to develop revolutionary processes for low cost extraction of titanium metal from oxide ores. The approaches include electrolytic processes that are similar to those developed for aluminum and which reduced its cost from that of a precious metal to an everyday material.

One more example is the Morphing Aircraft Structures program, which is developing technologies aimed at building air vehicles that can radically change their shape in-flight. This would allow a plane to fundamentally and dynamically vary its flight envelope, much like a bird does, so that a single air vehicle could perform multiple, radically different missions.

4.2. Microsystems

Microsystems – microelectronics, photonics, and microelectromechanical systems (MEMS) – are key technologies for the U.S. military, enabling it to see farther, with greater clarity, and better communicate information in a timely manner.

DARPA is building on these accomplishments by shrinking ever-more-complex systems into chip-scale packages – integrating the three core hardware technologies of the information age into "systems-on-a-chip." It is at the intersection of microelectronics, photonics, and MEMS that some of the greatest challenges and opportunities for DoD arise. Examples include integrating MEMS with radio frequency electronics and photonics; integrating photonics with digital and analog circuits; and integrating radio frequency and digital electronics to create mixed signal circuits.

The model for this integration is the spectacular reduction in transistor circuit size under Moore's Law: electronics that once occupied entire racks now fit onto a single chip containing millions of transistors. As successful as this progress has been, the future lies in increasing the level of integration among a variety of technologies to create still-more-complex capabilities. DARPA envisions intelligent microsystems that enable systems with enhanced radio frequency and optical sensing, more versatile signal processors for extracting signals in the face of noise and intense enemy jamming, high-performance communication links with assured bandwidth, and intelligent chips that allow a user to convert data into actionable information in near-real-time.

Taken together, these capabilities will allow the U.S. military to think and react more quickly than the enemy and create information superiority by improving how warfighters collect, process, and manage information.

A good example of DARPA's current work in microsystems is the Chip-Scale Atomic Clock, which is using MEMS technology to place an entire atomic clock onto a single chip, reducing its size and power consumption by factors of 200 and 300, respectively (see Figure 15). Chip-scale atomic clocks will greatly improve the mobility and robustness of military communication and navigation devices. Frequency references from atomic clocks will improve communications channel selectivity and density. Atomic clocks will also enable ultra-fast frequency hopping for improved security, jam-resistance, and data encryption. In GPS receivers, they will greatly improve the jamming margin and help continuously track positions and quickly reacquire a GPS signal. In surveillance, atomic clocks will improve the resolution of Doppler radars and locate radio emitters.

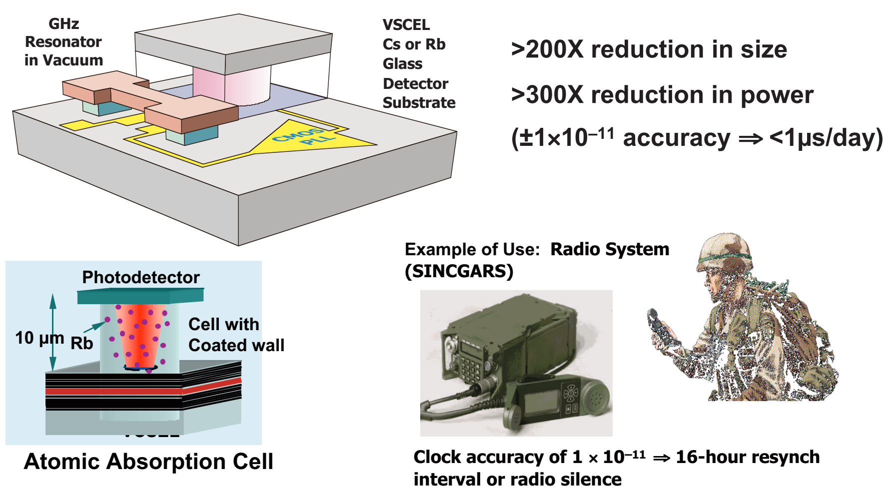

Figure 15: The Chip-Scale Atomic Clock: ultra-miniaturized, low-power, atomic time and frequency reference units.

Another example is the Molecular Electronics program. Within 10 to 15 years, today's dominant computer switch technology, CMOS[12] transistors, will reach its lower size limits and no longer advance according to Moore's Law. Anticipating this, the Molecular Electronics program is seeking to replace CMOS transistors with *molecular* switches that are 100 to 1000 times smaller and have the potential to reach a trillion switches per square centimeter. This development will reduce the size, weight, and power of these processors and increase their performance, allowing greater computing power to be packed into ever smaller volumes, increasing the "smarts" of military systems while lightening the soldiers' load. There has been solid progress towards this goal: in FY 2004, DARPA expects to demonstrate the first 16 kilobit memory based on molecular switches.

4.3. Information Technology

DARPA's strategic thrust in Cognitive Computing is significantly reshaping the Agency's enduring foundation in Information Technology. The six core Cognitive Computing research areas mentioned in Section 3.8 are setting the directions for DARPA's information technology research. These efforts will result in a new class of computational systems that will be responsible for their own operation and able to cope with unforeseen events. These systems will possess the ability to *reason* in a variety of ways, using substantial amounts of appropriately represented knowledge; they will *learn* from experiences and improve performance using accumulated knowledge; they will be able to *explain* themselves and *accept naturally expressed guidance and direction*; they will be *aware* of their own behavior; and most importantly, they will *respond* in a robust manner to surprises. DARPA envisions cognitive systems that possess *imagination* - the ability to invent interesting scenarios and plan for and predict novel futures.

DARPA's efforts build on traditional and revolutionary computing environments and strive to provide such things as improved device/system control, human-robot and robot-robot collaboration, and enhanced human cognition. Among our programs we have the following:

- DARPA's Software for Distributed Robotics (SDR) program is developing robot behavior and software to enable very large groups of very small, very inexpensive robots to perform useful tasks. SDR will allow human operators to control robot "swarms" without having to consider what each individual robot may be doing.

- Our High Productivity Computing Systems (HPCS) program is focusing on the *productivity* or *value* of a system, instead of its raw, theoretical computing speed, in order to improve by a factor of 10 to 40 the efficacy of high performance computers for national security applications. This program will maintain information superiority for the warfighter in areas that include weather and ocean forecasting, cryptanalysis, and computing the dispersal of airborne contaminants.

- Our Augmented Cognition program looks to directly (but non-invasively) measure human cognitive load so that information can be presented to the warfighter or commander in a way that does not overload human cognition when mental processes are pressed to the limit, and that takes advantage of spare mental "processing power." This will make those working under high-pressure circumstances much more effective, and will fundamentally change the nature of the human-machine interface, finally creating interfaces that adapt to the user rather than the other way around.

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[12] Complementary Metal Oxide Semiconductor

- DARPA's new Enduring Personalized Cognitive Assistant (EPCA) program will launch the creation of intelligent personalized assistants for many tasks (it imagines the potential for a commander's assistant, an intelligence analyst's assistant, and a decision-maker's executive assistant). These assistants will learn about preferences and procedures by observing their partner humans, but will also accept direct, naturally-expressed guidance. They will anticipate the human's needs and prepare materials to be ready just in time for their use. These new and unprecedented artificial helpers will help reduce staffing needs in many key places and will help make sure decisions are made in a timely fashion and with the best possible preparation. Successful implementation of an EPCA will help finally realize Licklider's vision of human-computer symbiosis.

Information technology at DARPA has been instrumental in many crucial developments: the mouse, firewalls, asynchronous transfer mode, synchronous optical networks, TCP/IP, packet-switching, search engines, and natural language processing. Twenty years from now, today's research will have enabled a new and scarcely imaginable legacy of robotics, network-centric warfare, and cognitive systems.

5. DARPA's Strategic Thrusts and QDR Operational Goals for Transformation

In the Quadrennial Defense Review (QDR), the Secretary of Defense established six critical operational goals for transforming the Department of Defense.[13] Figure 16 maps DARPA's eight strategic thrusts against those six goals to show how DARPA's current strategy continues to be a technological engine for transformation in the Department of Defense.

QDR Operational Goals for Transformation	DARPA's Strategic Thrusts
Protecting critical bases of operations (U.S. homeland, forces abroad, allies, and friends) and defeating chemical, biological, radiological, nuclear, and enhanced high explosive (CBRNE) weapons and their means of delivery	**Counter-terrorism**
Assuring information systems in the face of attack and conducting effective information operations	**Robust, Self-Forming Networks**
Projecting and sustaining U.S. forces in distant anti-access or area-denial environments and defeating anti-access and area-denial threats	**Networked Manned and Unmanned Systems** **Bio-Revolution**
Denying enemies sanctuary by providing persistent surveillance, tracking, and rapid engagement with high-volume precision strike, through a combination of complementary air and ground capabilities, against critical mobile and fixed targets at various ranges and in all weather and terrains	**Detect, Identify, Track and Destroy Elusive Surface Targets** **Characterization of Underground Structures** **Bio-Revolution**
Enhancing the capability and survivability of space systems and supporting infrastructure	**Assured Use of Space**
Leveraging information technology and innovative concepts to develop an interoperable, joint C4ISR architecture and capability that includes a tailorable joint operational picture	**Robust, Self-Forming Networks** **Cognitive Computing**

Figure 16: Mapping DARPA's strategic thrusts into QDR operational goals for transformation.

13 *Quadrennial Defense Review Report*, p. 30 (September 2001)

In a broader perspective, going beyond DARPA's eight strategic thrusts, approximately 90 percent of DARPA's investments can be mapped into the six QDR goals as shown in Figure 17. The remaining 10 percent of DARPA's budget is largely allocated to basic research and Small Business Innovation Research.

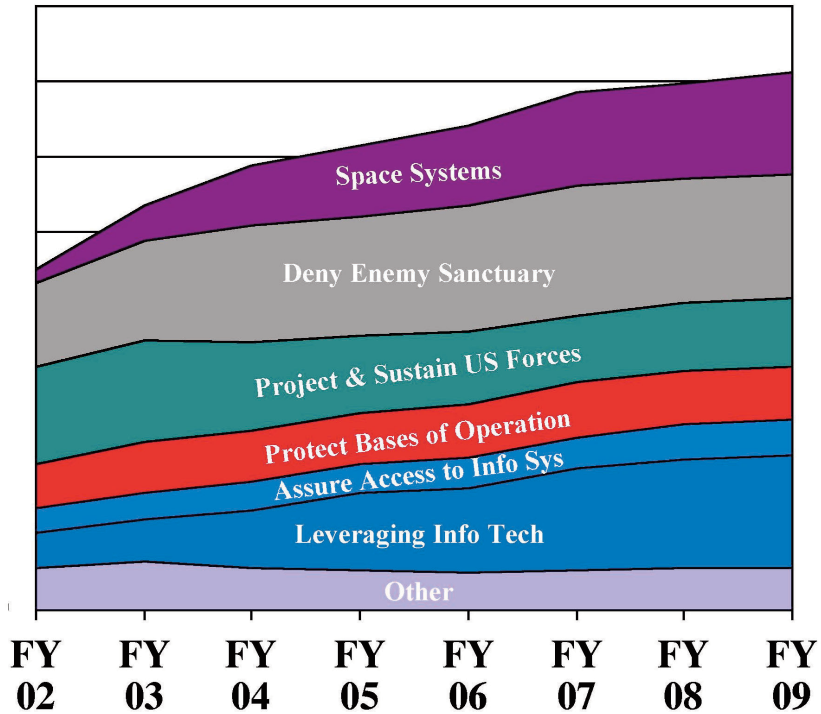

Figure 17: DARPA's budget by QDR transformation goals, FY 2002 - FY 2009.

6. Where To Find More Information

For information on DARPA's Offices and programs, please visit DARPA's website, www.DARPA.mil.

The DARPA Director's April 10, 2002, testimony to the Subcommittee on Emerging Threats and Capabilities, Committee on Armed Services, U.S. Senate, may be found at http://www.darpa.mil/body/NewsItems/pdf/DARPAtestim.pdf.

A fact file has been assembled as a ready reference for those interested in DARPA's research portfolio. This fact file contains short summaries of selected DARPA programs in FY 2003, and it may be found at http://www.darpa.mil/body/NewsItems/darpa_fact.html. This document will be updated for FY 2004.

DARPA has four Military Operational Liaisons who serve as points of contact for each Service:

Army:	LTC Dave Redding (703) 696-2438, dredding@darpa.mil
Navy:	CAPT Christopher R. Earl (571) 218-4219, cearl@darpa.mil
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DARPA's Military Operational Liaisons may be contacted via SIPRNET at [username]@darpa.smil.mil